



LAWRENCE  
LIVERMORE  
NATIONAL  
LABORATORY

# Compilation of Criteria and Summaries from B332 Seismic Evaluations for the Initial Scoping Document Release of the HS-45 LLNL Audit, February 7, 2013

M. Sampson

February 7, 2013

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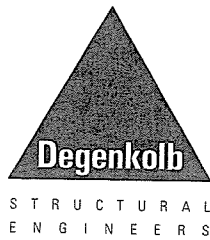
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

**Compilation of Criteria and Summaries from B332 Seismic Evaluations  
for the  
Initial Scoping Document Release of the  
HS-45 LLNL Audit**

**February 7<sup>th</sup>, 2013**

**Contents:**

- 1. Seismic and Wind Evaluation of the Lawrence Livermore National Laboratory Building 332, January 21, 1992, Revised June 24, 1992 (initial 7 pgs, I-1 thru I-3, II-1 thru II-4, III-1 thru III-6, 20 pages total)**
- 2. LLNL – Building 332 Critical System Evaluation Calculations, Volume 1, June 30, 1989 (first 8 pages)**
- 3. LLNL – Building 332 Critical System Evaluation Calculations, Volume 2, June 30, 1989 (first 12 pages)**
- 4. LLNL – Building 332 Critical System Evaluation Calculations, Volume 3, June 30, 1989 (first 7 pages)**
- 5. LLNL – Building 332 Critical System Evaluation Calculations, Volume 4, June 30, 1989 (first 5 pages)**
- 6. LLNL – Building 332 Critical System Evaluation Calculations, Volume 5, June 30, 1989 (first 11 pages)**
- 7. LLNL – Building 332 Critical System Evaluation Calculations, Volume 6, June 30, 1989 (first 11 pages)**



7/9

**SEISMIC AND WIND  
EVALUATION OF THE**

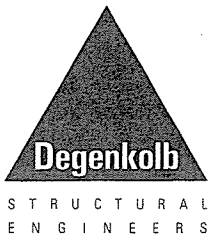
***LAWRENCE LIVERMORE  
NATIONAL LABORATORY  
BUILDING 332***

**by**

**H.J. Degenkolb Associates,  
Engineers**

**January 21, 1992**

**Revised June 24, 1992**



June 24, 1992

Gary Freeland - L-654  
Lawrence Livermore National Laboratory  
700 East Avenue, Suite 2300  
Livermore, California 94550

Reference: **SEISMIC AND WIND EVALUATION  
LLNL BUILDING 332  
[DEGENKOLB JOB NO. 89089.01]**


Gentlemen:

We are pleased to submit our report *Seismic and Wind Evaluation of the Lawrence Livermore National Laboratory Building 332*.

The calculations supporting this report are bound as separate appendices.

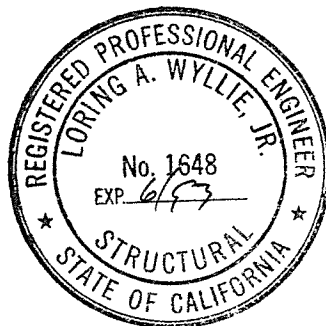
Very truly yours,


H.J. DEGENKOLB ASSOCIATES, ENGINEERS

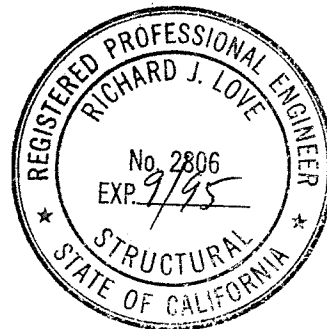
  
Loring A. Wyllie, Jr.

LAW/cc

P:\Project.89\89089



  
Richard Jay Love



H. J. Degenkolb Associates,  
Engineers

350 Sansome Street  
Suite 900  
San Francisco C.A. 94104  
Phone 415.392.6952  
Fax 415.981.3157  
Emergency 916.552.1440

Henry J Degenkolb  
1913-1989

Chris D Poland  
Loring A Wyllie Jr  
David R Bonneville  
Thomas D Wosser

Ted J Canon  
George E Greenwood  
Richard Jay Love  
Maryann T Phipps  
David W Cocke  
James O Malley  
John A Dal Pino

## EXECUTIVE SUMMARY

H. J. Degenkolb Associates has performed an evaluation of Building 332 at Lawrence Livermore National Laboratory (LLNL) for wind and seismic effects. The evaluation was done following the guidelines of UCRL-15910, "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards." Building 332, consisting of several structures, [REDACTED]

[REDACTED] Because the building [REDACTED] is designated as a High Hazard Facility. LLNL provided the seismic response spectra for this evaluation. The LLNL Design Basis Earthquake Spectra has an effective peak ground acceleration of 0.82g applied in both the horizontal directions and the vertical direction simultaneously.

This study consists of separate evaluations of Increment I, Increment III and the Plenum Building. The analysis was limited to the structural components of these structures and did not include architectural features, components nor mechanical or electrical equipment or systems. The seismic analysis was an elastic dynamic analysis following the UCRL-15910 guidelines.

Building 332 was built in several stages. Increment I was constructed in 1961, Increment III in 1978, and the Plenum Building in 1981. Following the 1980 Greenville earthquake, LLNL strengthened several portions of Increment I, specifically the Loft Roof, the precast panels surrounding the loft and portions of the Mechanical Equipment Room and Office area. This report discusses each portion of Building 332 separately in the report with a building description, a discussion of the specific analysis procedures, and the results of the evaluation. It should be noted that the evaluation criteria for this review are considerably more severe than both the criteria for the original design and the structural upgrades that followed the Greenville Earthquake.

The wind loading criteria for the structures as a whole are not as critical as the seismic criteria, therefore, we have not performed detailed analyses using wind loading. For the wind-driven missile, the structure is adequate except the metal siding of the Increment I Mechanical Room. A wind-driven missile (a fifteen pound 2x4 impacting at fifty miles per hour) can penetrate the exterior metal siding and could potentially damage interior contents mounted to the interior side of the exterior walls.

The seismic analysis of the structure has exposed many structural elements where the demand-to-capacity ratios are greater than 1.0, indicating the specific structural elements do not meet the criteria. It is our opinion that most of these conditions of apparent overstress are due to the extreme severity of the criteria and the fact that an elastic analysis was performed and inelastic response will reduce the demand significantly more than provided by the  $F_u$  term in UCRL-15910. In addition, many of the conditions of apparent overstress are in minor connections where metal might bend but the consequence of the "failure" will not, in our opinion, affect the functioning of the building and its systems. We provide a detailed description of the features with a demand-to-capacity ratios greater than 1.0 in the discussion of each building. We also include our comments and recommendations.

We do recommend that LLNL consider strengthening several conditions within Building 332 in the interest of life-safety and improved seismic performance. Specifically, unreinforced masonry wall on line 6 of Increment I and the non-ductile concrete beams on the same line which support steel bracing for Loft Roof should probably be strengthened similar to previous strengthening of similar conditions on line 5. Additionally, the connection of the Mechanical Room roof at B-5 in Increment I could be strengthened as other roof connections along line 5 were strengthened. These items are in Table IV-1 and specifically Comments Number 1, 24 and 35 address these issues.

## Degenkolb

Building 332 is an inherently stout and rugged building with the extensive reinforced concrete walls of the Radioactive Materials Area (RMA) and the strengthened steel frame roofs of the Loft and Mechanical Room. We have recommended strengthening Line 6 to brace the masonry infill walls and adequately support the loft roof brace points on the concrete beams on that line. With this strengthening, it is our opinion that there are no seismic life safety issues in Building 332. While we have identified conditions in the metal roof structures where metal might bend in the specified earthquake and the metal siding of the Mechanical Room may be penetrated by a specified wind driven missile, it is our opinion that the structure of Building 332 should provide a satisfactory structural confinement barrier for hazardous radioactive materials as defined in DOE Guidelines UCRL-15910 once the minor strengthening recommendations are completed.



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## I. INTRODUCTION

The Lawrence Livermore National Laboratory (LLNL) contracted with H. J. Degenkolb Associates, Engineers, to evaluate three structures of the Building 332 Facility in Livermore, California. Degenkolb performed this study under Subcontract No. 5416000 to the Regents of the University of California.

Building 332, shown in Figure I-1, is a plutonium facility where hazardous radioactive materials are located. The effects of natural phenomena hazards such as earthquakes and high winds pose safety risks to the structures, to people within the structures, to the hazardous contents, and to the environment around the structure.

LLNL previously studied this facility in 1981 using the seismic criteria current at that time. The criteria for the present study supersede the criteria of the earlier study.

## Purpose Of Evaluation

The purpose of this evaluation is to update previous seismic hazard studies of Building 332 using the latest criteria for expected structural performance based on appropriate seismic force levels. The new criteria are provided in *UCRL 15910 - Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards* (Reference 1).

This evaluation identifies those structural components that do not meet the criteria when considering the importance of this facility. The Scope of Work limits the study to the building structures that contain the hazardous materials or are essential for the safety of the areas where hazardous materials are located. These structures are the final barrier providing containment of the hazardous materials. The two other containment barriers, the ventilation system and the glove box systems, are not included in this report. (Degenkolb provided a separate, previous evaluation of the critical ventilation systems using UCRL 15910 criteria under this subcontract.)

Based on the results of the evaluation, this report provides recommendations for mitigation of deficiencies or changes in the criteria.

## Scope Of Work

This study includes the following structures, shown in Figure I-2:

1. Increment I including the Radioactive Materials Area (RMA), the second story Mechanical loft above the RMA, the Mechanical Room Area.
2. Increment III
3. Plenum Building

This study does not include the following structures:

1. Increment II
2. Building 335
3. Increment I office areas except where the office area structure affects seismic response of the Increment I Mechanical Loft and RMA.

## II. BACKGROUND INFORMATION

Lawrence Livermore National Laboratory was shaken by two earthquakes in January 1980 that originated from the nearby Greenville fault. The Richter magnitudes of the earthquakes were M5.5 and M5.8 [Reference 2]. There was damage to various buildings at the Lab as a result of the ground shaking. Building 332 experienced some damage including minor cracking in the walls and floors of Increment I and significant damage to the concrete masonry block walls of the Office Wing and the Mechanical Equipment Room. There was no damage reported in Increment III nor within the RMA.

As a result of the damage at the site and within the Office Wing of Building 332, the Department of Energy commissioned a study of the structures and the equipment contents that comprise the Building 332. This study was conducted by an Independent Review Committee (IRC) consisting of H. J. Degenkolb Associates, Brandow and Johnston Associates, Structural Mechanics Associates (SMA), Dr. William Hall, and Dr. Mete Sozen.

While the IRC Review was in progress, LLNL contracted with Ruth and Going, Structural Engineers, to prepare design documents for the repair and strengthening of Increment I as a result of the 1980 earthquake damage. As part of their work, the original exterior concrete masonry walls of the Mechanical Room were replaced with lightweight metal panels, the Mechanical Room roof diaphragm was strengthened, and some interior concrete masonry walls were repaired and strengthened. Their design documents were complete in May 1981. The construction was complete in February 1982.

## Degenkolb

While the Ruth & Going seismic upgrade project was in progress, the Independent Review Committee issued a report titled *Seismic Evaluation of the LLNL Plutonium Facility (Building 332)* to the Department of Energy [Reference 3]. The IRC incorporated the design work of Ruth & Going into that study.

The report, issued in March 1982, provided a consensus opinion based on the independent seismic evaluations prepared by Degenkolb, Brandow and Johnston, and SMA. These independent studies were included as appendices to the joint IRC report. The report included evaluations of the anticipated behavior of the building structures as well as the critical systems of the buildings.

The evaluation criteria for the IRC study included three postulated levels or types of earthquake ground motion. The first earthquake was based on a 0.5g peak ground acceleration and the LLNL response spectral shape, Figure II-1. The second earthquake was based on the same spectral shape but with a 0.8g peak ground acceleration. The third earthquake was defined as the same ground motion as the second earthquake with a superimposed single acceleration spike of 1.2g. In all three earthquakes, the vertical acceleration was set at two-thirds the horizontal accelerations. These three ground motion response spectra were deemed to envelope the responses expected from the maximum credible earthquakes generated from the San Andreas, Hayward, Calaveras, and local, smaller faults.

The firms involved approached the evaluation in different manners. However, in general, all firms employed linear-elastic computer models of the structures for use in dynamic analysis computer programs. Structural capacities of members were based on yield-level code allowable capacities including capacity reduction factors combined with ductility reduction factors to account for limited inelastic behavior of the members.

## Degenkolb

The March 1982 report concluded that some damage to the buildings, glove boxes, and ventilation systems could be expected as a result of the postulated earthquake motions specified for that study. In Increment I, the IRC concluded that the Mechanical Loft Roof structure, the Mechanical Loft braced frames, exterior precast panels, Mechanical Equipment Room roof and concrete piers could be damaged in the event of a major earthquake. The report recommended strengthening of the roof diaphragm, braced frames, and precast panels. Increment III was deemed adequate to resist the postulated earthquakes.

As a result of this report, the Laboratory commenced a seismic upgrade project to correct the deficiencies cited in the report. Frederiksen Engineering prepared construction documents in 1982 for the seismic strengthening of the Mechanical Loft Roof, the loft braced frames, the connections of the second story exterior precast panels to the structure and strengthened connections between the Mechanical Room Roof and the RMA. The construction was completed in May 1983.



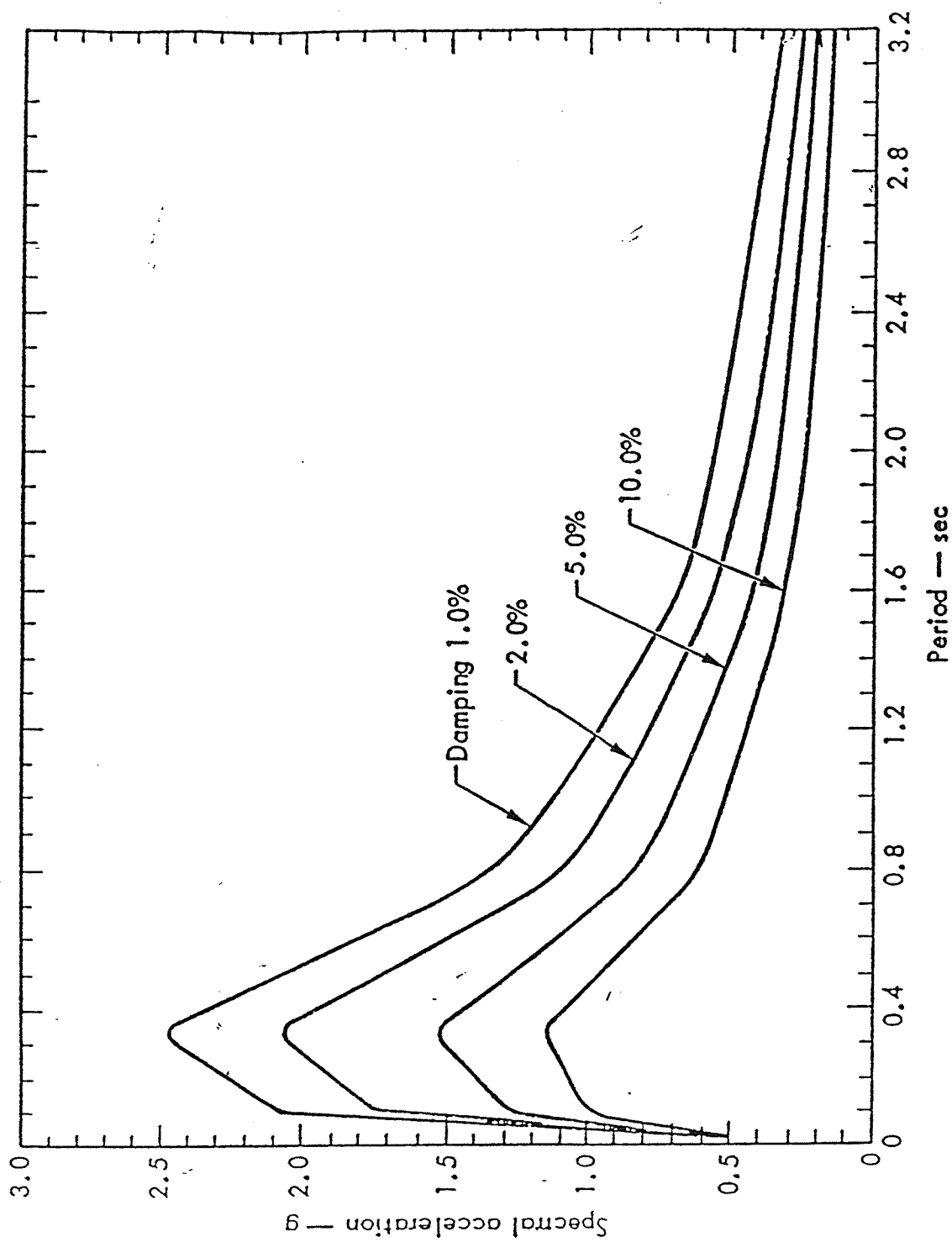


FIGURE II-1 - 1982 LLNL DESIGN RESPONSE  
SPECTRUM ANCHORED TO A DESIGN GROUND ACCELERATION OF 0.5 g

### III. EVALUATION CRITERIA

This study has been conducted using the criteria established in UCRL-15910. This document provides "uniform design and evaluation guidelines for protection against natural phenomena . . ." including earthquakes, strong winds, tornadoes and flooding. DOE Order 6430.1A references UCRL 15910 as an acceptable approach for the evaluation of DOE facility structures. LLNL directed that this study incorporate the UCRL guidelines but with specific exceptions related to the site spectra and vertical accelerations as noted below.

The UCRL Guidelines attempt to control the amount of conservatism in the evaluation process to match the importance of the specific facility. The importance of a facility is judged by several factors including the usage of the building, cost to repair damage, hazardous exposure to people on and off site, and environmental hazards.

The Guidelines define the following issues for the review of any structure:

Usage Category and Performance Goals.

Hazard probability to define loading.

Recommended evaluation procedures to assess whether the computed response of the structure is acceptable.

LLNL designates the Usage Category for Building 332 as a High Hazard Facility. This Usage category is the most severe of four categories. The other three categories, in order of ascending importance, are 1. General Use Facilities, 2. Important or Low Hazard Facilities, and 3. Moderate Hazard Facilities. These categories are explained in Table 2-1 of the Guidelines.

The High Hazard category is appropriate for facilities where the confinement of contents is critical for the protection of the public and environment. It is important that these types of facilities possess a very small potential for damage. As such, the Guidelines are more conservative for the High Hazard Facilities than for other categories.

UCRL 15910 specifies Performance Goals for structures in a probabilistic manner. The performance goal for a High Hazard facility includes providing occupant safety and a high confidence level that the hazardous contents will remain confined during and after a major event. The probability is expressed as an acceptably low annual probability of exceedance that the facility cannot perform in a satisfactory manner. For High Hazard facilities, the probability of exceedance should not be greater than  $10^{-5}$  in order to maintain hazardous material confinement.

The hazard exceedance probability for earthquakes established in UCRL 15910 for High Hazard facilities is  $2 \times 10^{-4}$ . For comparison, the hazard exceedance probability for General Use buildings is  $2 \times 10^{-3}$ , a factor of ten greater than High Hazard buildings.

## Degenkolb

UCRL 15910 provides Peak Ground Accelerations (PGA) for each DOE site for each specified Hazard Annual Probability of Exceedance. However, for this review, LLNL directed that the study base its seismic motion input on LLNL Design Basis Earthquake Response Spectra, represented by Newmark Hall median ground response spectra, Figure III-1. The PGA was set at 0.82 g to represent the effective peak ground acceleration at the site. (It should be noted that Table 4-4 in UCRL 15910 specifies a PGA of 0.68g for a Annual Probability of Exceedance of  $2 \times 10^{-4}$  earthquake.) The effective peak ground acceleration applies to passive component functions, defined as structures or components whose functionality is static in nature such as piping, ducting and building structures. No additional modifications to the PGA were allowed for this review. This response spectrum, including the Peak Ground Acceleration, supersedes information provided in UCRL 15910, Table 4-4 "Maximum Horizontal Ground Surface Accelerations at DOE Sites."

In addition to the revision to the response spectrum, LLNL directed that the vertical peak ground acceleration equal the horizontal peak ground. The vertical spectrum is applied simultaneously with the two horizontal seismic components. This exceeds the common practice to assume the vertical acceleration equals two-thirds of the mean horizontal peak acceleration.

UCRL 15910 requires that the maximum spectral acceleration given on the response spectrum be used for the fundamental mode of vibration of the building when calculating modal forces on short, stiff buildings. For higher modes of vibration, the actual spectral acceleration may be used to calculate the modal forces. In general, this is accomplished by identifying the fundamental period of vibration and then modifying the shape of the response spectrum, if necessary, such that the maximum application range includes this period of vibration.

Modal results for each of two horizontal directions plus the vertical direction are combined using either the Square Root Sum of the Squares method (SRSS) or the Complete Quadratic Combination method, an improvement of the SRSS method when there are closely spaced modes of vibration. Note that commonly used seismic provisions such as the UBC do not require that the vertical component be included in the combination of forces.

The basic evaluation procedure, given in Table 4-5 of UCRL 15910, consists of the following steps:

1. Evaluate dead and realistic live loads for all elements.
2. Perform elastic dynamic analysis of the building using the specified response spectra to determine seismic forces in all structural members.
3. Reduce the elastic demand forces using Inelastic Demand Capacity ratios,  $F_u$  values. These values take into account the expected available ductility inherent in different types of construction.
4. Evaluate the total demand forces as the sum of the dead plus live loads and the inelastic seismic demand forces.
5. Evaluate capacities of members using code ultimate or yield level stresses based on the minimum specified material strengths. No in-situ material testing was performed for this evaluation.

## Degenkolb

6. Evaluate whether the member capacities exceed the member total demand forces.
7. Evaluate story drifts due to lateral forces. Acceptable drifts are defined as 0.010 times the story height for High Hazard facilities.
8. Check elements for good detailing practice for seismic load resisting elements.

L.L.N.L. DESIGN BASIS EARTHQUAKE  
HORIZONTAL AND VERTICAL GROUND RESPONSE SPECTRA  
PEAK GROUND ACCELERATION NORMALIZED TO 1g  
 NEW MARK-HALL MEDIAN SPECTRA 2% - 15% DAMPED

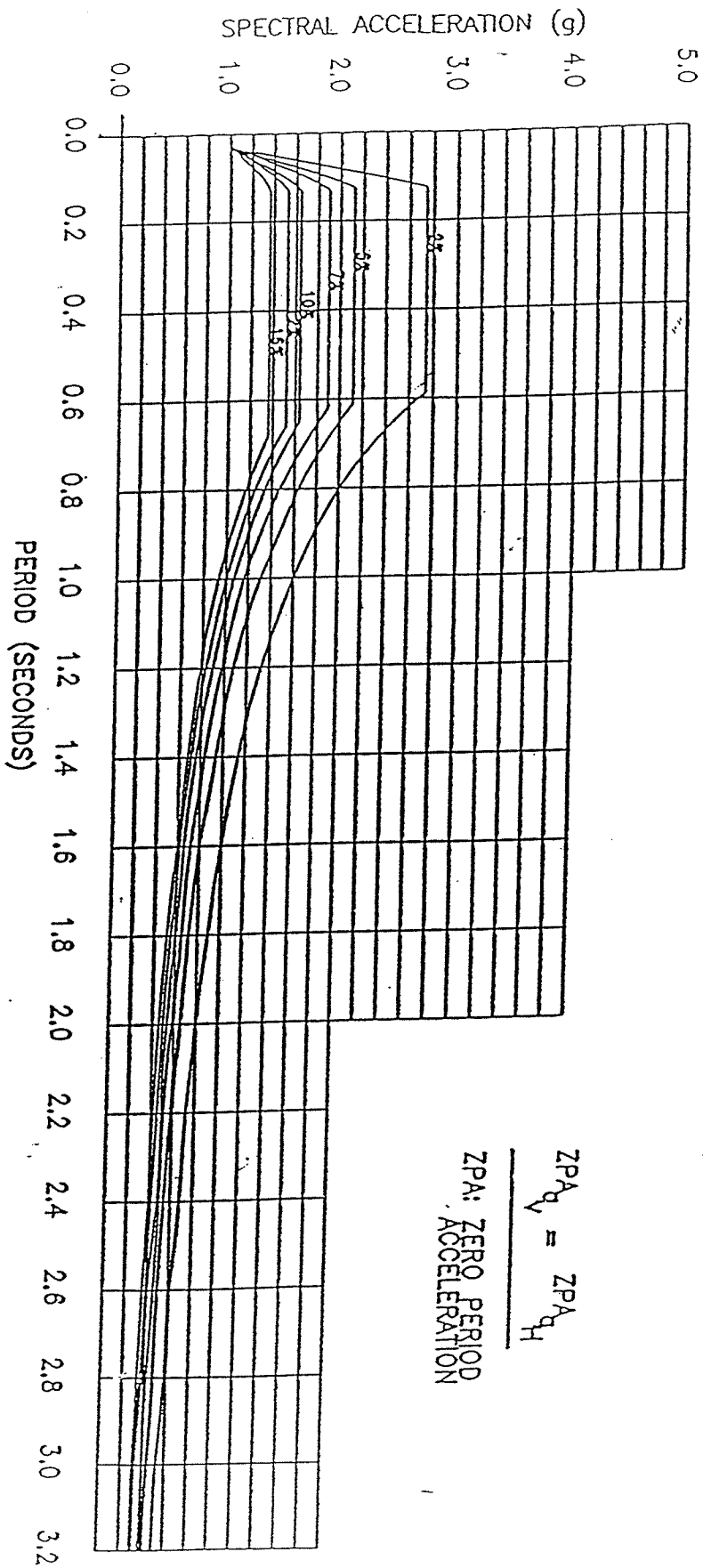


FIGURE III-1 - 1991 LNL DESIGN RESPONSE  
 SPECTRUM NORMALIZED TO 1.0 g

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**LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS**

*Volume 1*

**HJDA JOB #89089**

**JUNE 30, 1989**

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350 Sansome Street  
Suite 900  
San Francisco, CA  
94104

415-392-6952  
Fax 415-981-3157

**H. J. Degenkolb Associates, Engineers**

**Degenkolb**

A California Corporation  
practicing in the broad field  
of Structural Engineering



**INDEX - CALCULATIONS**

**VOLUME 1:      RESPONSE SPECTRA DEVELOPMENT**  
**ATMOSPHERIC REFERENCE SYSTEM**  
**FIRE SUPPRESSION SYSTEM**

Subject:

CRITERIA - RESPONSE SPECTRA

350 Sansome Street

San Francisco, CA

94104

415-392-6952

Job:

LINK #332

Job Number:

89089

Date:

6/29

H. J. Degenkolb Associates, Engineers

By:

WKE

Section:

1

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Of:

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DEVELOPMENT OF  
RESPONSE SPECTRA  
FOR  
EVALUATION OF  
PIPING  
AND  
DUCTS

Subject:

EARTHQUAKE SPECTRA

Job: LLNL BLDG 332

Job Number: 89089 Date: 6/20/89

By: UHF Section: 1

Checked by: \_\_\_\_\_ Page: ( Of: \_\_\_\_\_

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San Francisco, CA  
94104  
415-392-6952

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RESPONSE SPECTRA FOR EVALUATION

AS DISCUSSED IN THE REPORT ON THIS EVALUATION THE GROUND MOTION RESPONSE SPECTRA FOR THE LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) SITE HAVE THE SHAPES SHOWN ON PAGE 3 OF THIS SECTION. THESE SHAPES CONFORM TO THOSE PRESCRIBED IN DEVELOPMENT OF CRITERIA FOR SEISMIC REVIEW OF SELECTED NUCLEAR POWER PLANTS BY N.H. NEWMARK AND W.J. HALL [NUREG/CR-0098, MAY 1978] AND ARE NORMALIZED TO  $1.0g$  ZERO PERIOD ACCELERATION (ZPA).

AS DISCUSSED IN THE REPORT, THESE SHAPES ARE ADJUSTED TO A  $0.002g$  ZPA BASED ON A WOODWARD-CLYDE STUDY WHICH RECOMMENDED A  $0.08g$  PEAK GROUND ACCELERATION AND ON THE 10% REDUCTION PROPOSED BY DESIGN AND EVALUATION GUIDELINES FOR DEPARTMENT OF ENERGY FACILITIES SUBJECTED TO NATURAL PHENOMENA HAZARDS BY R.P. KENNEDY ET AL [UCRL-15910, MAY 1989]. THE ADJUSTED SHAPE FOR 5% DAMPING IS SHOWN ON PAGE 4 OF THIS SECTION AND IS LABELED "N-H 5% DAMPING".

ALSO, AS DISCUSSED IN THE REPORT, SHOWN ON PAGE 4 ARE THE SPECTRA "AEC-0.5g-5% DAMPING" AND "AEC-0.002g-

Subject:

EARTHQUAKE SPECTRA

Job: LNK BLDG 332

Job Number: 89089

Date: 6/20/89

By: MZ

Section: 1

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415-392-6952

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5% DAMPING". THE "AEC-0.5g-5% DAMPING" SPECTRUM IS THE 5% DAMPED GROUND MOTION SPECTRUM USED IN THE 1981 EVALUATION OF THE BUILDING BY H.J. DEGENKOLB ASSOCIATES, STRUCTURAL MECHANICS ASSOCIATES AND BRAWDOW AND JOHNSTON, THE "AEC-0.702g-5% DAMPING" SPECTRUM IS THE "AEC-0.5g-5% DAMPING" SPECTRUM ADJUSTED TO A ZPA OF 0.702g.

Subject:

DESIGN BASIS EQ SPECTRUM

Job: LNL BLDG 332

Job Number: 29089

Date: 6/3/89

By: MZ

Section: 1

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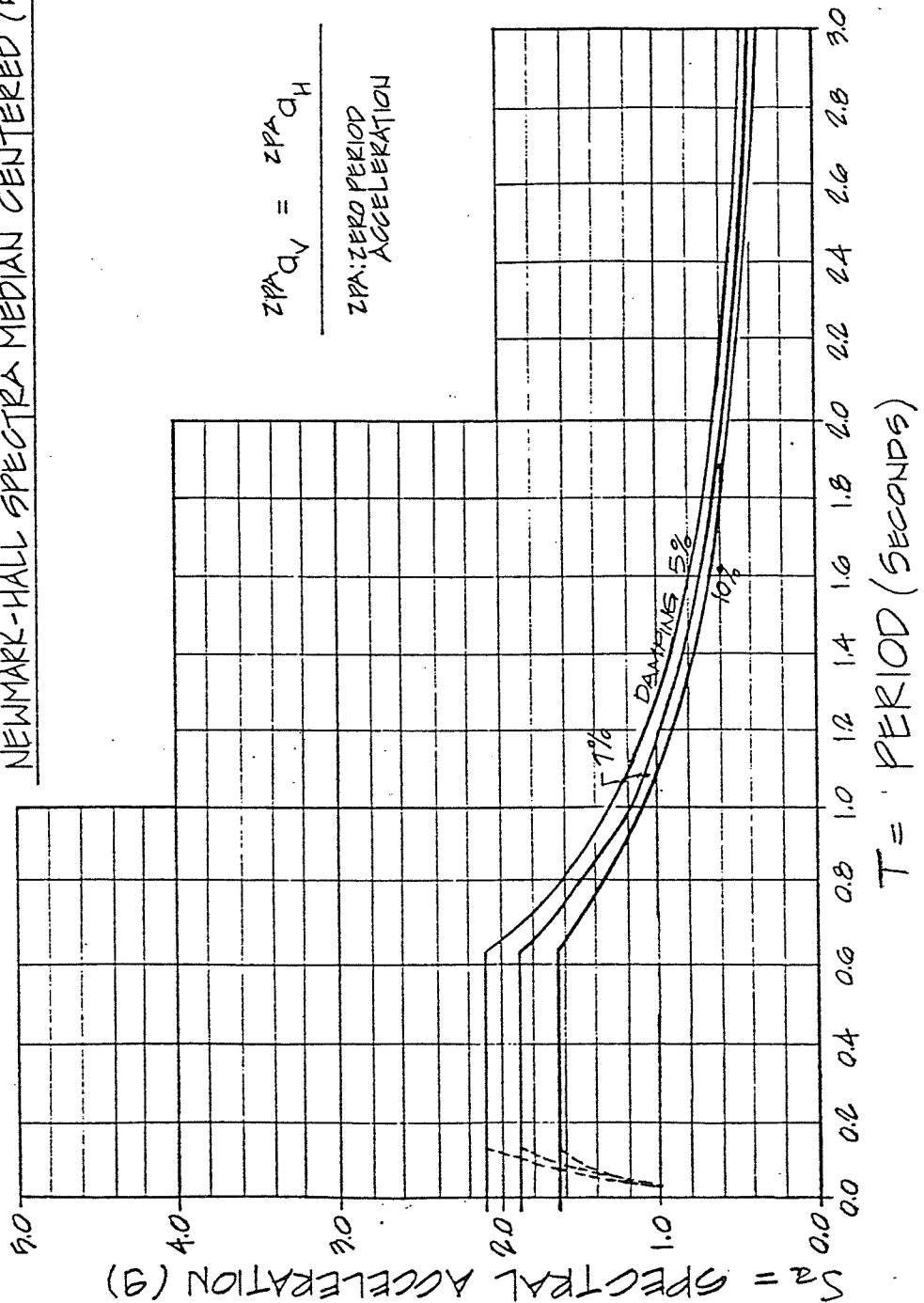
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L.L.L. DESIGN BASIS EARTHQUAKE  
HORIZONTAL AND VERTICAL GROUND RESPONSE SPECTRA  
PEAK GROUND ACCELERATION NORMALIZED TO 1g  
NEWMARK-HALL SPECTRA MEDIAN CENTERED (50%)



Subject: NEWMARK/HALL RESP SPECT. VS  
SMA HORIZ GROUND RESP. SPECTRA

350 Sansome Street  
San Francisco, CA  
94104  
415-392-6952

Job: LLNL BLDG 382

Job Number: 89087

Date: 6/13/89

H. J. Degenkolb Associates, Engineers

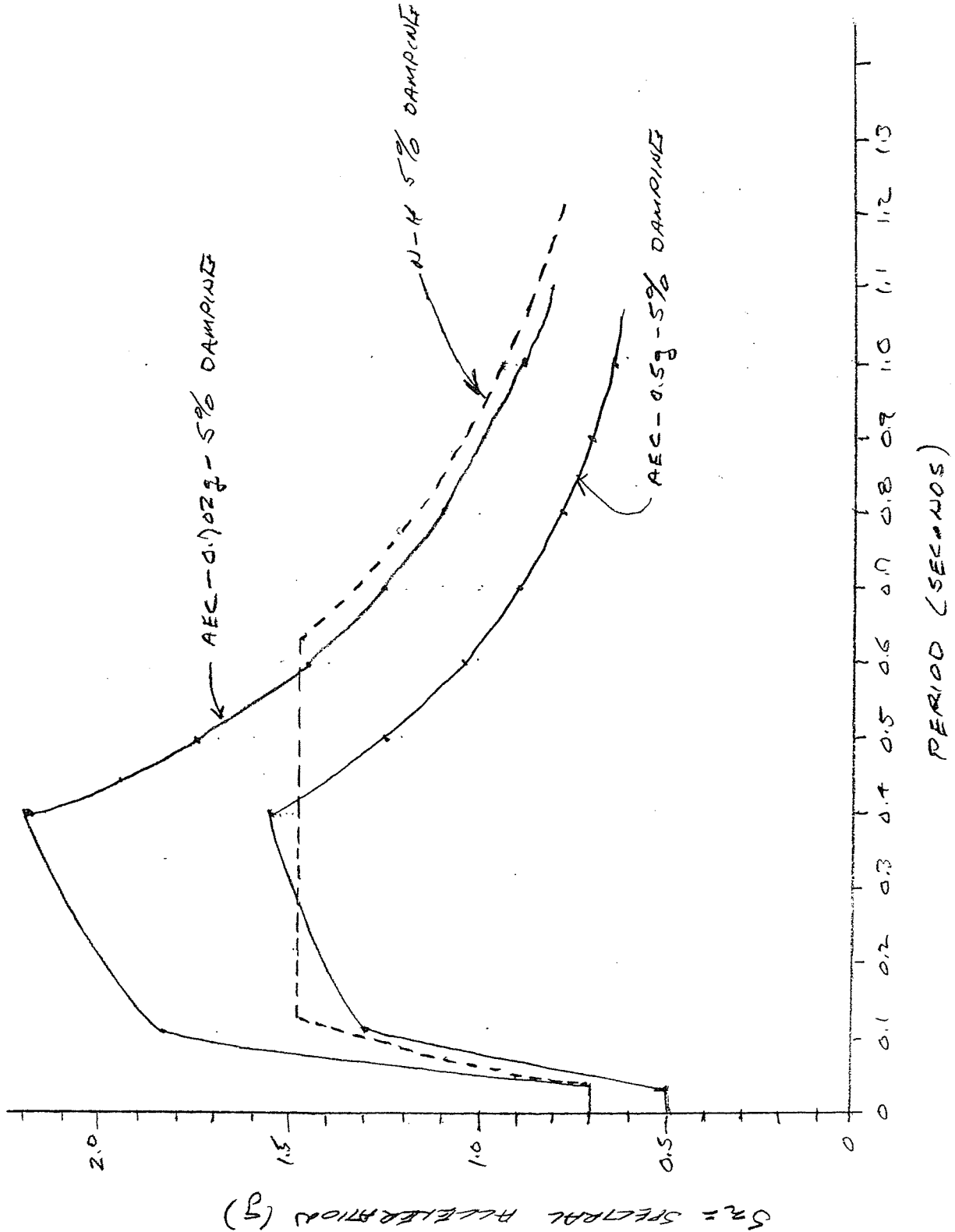
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**Degenkolb**



Subject:

GROUND MOTION SPECTRUM

Job: LNL BLDG 332

Job Number:

Date: 6/13/89

By: ME

Section: 1

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350 Sansome Street

San Francisco, CA

94104

415-392-6952

H. J. Degenkolb Associates, Engineers

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COORDINATE PAIRS OF PERIOD-SPECTRAL  
ACCELERATION FOR 5% DAMPING

$T = \text{PERIOD}$        $S_2 = \text{SPECTRAL ACCELERATION}$

FOR  $0 < T < 0.0303 \text{ SEC}$  (33 HZ)

$$S_2 = 0.702g$$

FOR  $0.125 \text{ SEC}$  (8 HZ)  $< T < 0.625 \text{ SEC}$  (1.6 HZ)

$$S_2 = 2.12 \times 0.702g = 1.49g$$

2.12 = SPECTRAL AMPLIFICATION  
FACTOR FOR 5% DAMPING  
PER NEWMARK/HALL WHICH  
IS SHOWN ON SPECTRA PLOT P.3

FOR  $0.0303 < T < 0.125 \text{ SEC}$ .

$S_2$  VARIES BETWEEN  $0.702g$   
AND  $1.49g$ . THE VARIATION IS  
SUCH THAT WHEN THE SPECTRUM  
IS PLOTTED ON TRIPARTITE GRAPH  
PAPER THIS PORTION OF THE  
SPECTRUM IS A SLOPING LINE  
ON THE GRAPH WHEREIN THE  
ABSCISSA IS FREQUENCY ( $\frac{1}{\text{PERIOD}}$ )

AND THE ORDINATE IS SPECTRAL  
VELOCITY - SEE EXAMPLE NEXT  
PAGE SHOWING VARIATION OF  
 $S_2$

HENCE, THE VARIATION OF SPECTRAL  
VELOCITY IN THIS RANGE CAN  
BE EXPRESSED AS

— GO TO BOTTOM NEXT PAGE —

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**LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS**

*Volume 2*

**HJDA JOB #89089**

**JUNE 30, 1989**

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350 Sansome Street  
Suite 900  
San Francisco, CA  
94104

415-392-6952  
Fax 415-981-3157

**H. J. Degenkolb Associates, Engineers**

**Degenkolb**

A California Corporation  
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**INDEX - CALCULATIONS**

**VOLUME 2:      HEALTH PHYSICS VACUUM SYSTEM  
(CAM)**

**INCREMENT III GLOVE BOX EXHAUST  
(6 INCH DIAMETER PIPE)**

**ARGON & NITROGEN SYSTEM:  
INCREMENT I LOFT**

Subject:

GLOVE BOX EXHAUST & CAM

350 Sansome Street

San Francisco, CA

94104

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Job:

LLNL, Bldg. 332

Job Number:

89089

Date:

6-29-89

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By:

JFP

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## INCREMENT III

### GLOVE BOX EXHAUST SYSTEM &

### CONTINUOUS AIR MONITORING SYSTEM (CAM)

(SECTIONS 8.2 & 12 OF REPORT)

- 2.1 WORST CASE CRITERIA
- 2.2 MODEL DESCRIPTION
- 2.3 SAP90 MODEL DEVELOPMENT
- 2.4 GROUND RESPONSE SPECTRUM
- 2.5 GLOVE BOX EXHAUST & CAM SYSTEMS  
MODEL ANALYSIS
  - A) MODEL CHECK
  - B) DYNAMIC ANALYSIS SUMMARY
  - C) STRESS CHECKS
  - D) COMPUTER OUTPUT



Subject:

GLOVE BOX EXHAUST & CNM

Job:

LNL, Bldg. 330

Job Number:

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SECTION 2.1

WORST CASE CRITERIA

Subject:

GLOVE BOX EXHAUST / CRM

Job:

LLNL, Bldg. 332

Job Number:

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WORST CASE CRITERIA :

GENERAL :

- 1) BASED ON THE RESPONSE SPECTRA USED, SYSTEMS WITH LOWER FREQUENCIES WILL HAVE HIGHER RESPONSES.
- 2) LOW FREQUENCY SYSTEMS WERE DEFINED AS HAVING :
  - a) LONGEST SPANS
  - b) LARGEST MASS
  - c) LEAST MOMENT OF INERTIA
- 3) THEREFORE, CRITICAL CASES WERE DEFINED AS THE SECTIONS OF EACH SYSTEM THAT HAD THE LOWEST FREQUENCY.

GLOVE BOX EXHAUST SYSTEM & CRM SYSTEM :

BASED ON JUNE 15, 1989 SITE VISIT:

- LONGEST SPANS WERE 12'
- THE SUPPORT TRAPEZES SUPPORTED NUMEROUS PIPING LINES ADDING LARGE AMOUNTS OF MASS TO THE SUPPORT SYSTEM.



Subject:

GROVE Box EXHAUST & CRM

Job:

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Job Number:

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SECTION 2.2

MODEL DESCRIPTION

Subject:

GLOVE BOX EXHAUST / CNM

Job:

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Job Number:

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GLOVE BOX EXHAUST & CNM MODEL DESCRIPTION:

- 1) ANALYZE THE SUPPORT TRAPEZES, ~~THE~~ 6"  $\phi$  GLOVE BOX EXHAUST DUCT AND 2- 4"  $\phi$  CNM PIPING LINES.
- 2) INCLUDE IN THE MODEL THE OTHER PIPING AND CONDUIT LINES SO AS TO BETTER REPRESENT THE ACTUAL MASS AND STIFFNESS OF THE SYSTEM.
- 3) THE MODEL INCLUDES THREE FULL SPANS; 1 - 12' LONG AND 2 - 6' LONG. THE MODEL WAS EXTENDED TO INCLUDE THE 6' SECTIONS TO INCLUDE AN UNUSUAL TRAPEZE CONFIGURATION (CENTER TRAPEZE IN MODEL). ONE OF THE TRAPEZE'S ORIGINAL VERTICAL HANGERS HAD BEEN CUT OFF AND A NEW ONE INSTALLED IN A DIFFERENT LOCATION. THE NEW CONFIGURATION IS UNSYMMETRICAL. (SEE MODEL PLOTS AT END OF SECTION)
- 4) THE TYPICAL TRAPEZES CONSIST OF TWO VERTICAL 55x10 HANGERS, AN L 6x3 CROSS BEAM FOR THE UPPER LEVEL PIPING AND TWO VERTICAL L 2x2 HANGERS SUPPORTING A L 2x2 CROSS BEAM FOR THE LOWER LEVEL PIPING. THE CENTER TRAPEZE HAS AN L 3x3 REPLACING A 55x10.
- 5) THE UPPER LEVEL PIPING CONSISTS OF THE 6"  $\phi$  GLOVE BOX EXHAUST DUCT, BOTH 4"  $\phi$  CNM PIPES, 4- 2 1/2"  $\phi$  COPPER LINES, 2- 2"  $\phi$  COPPER LINES AND A 3/4"  $\phi$  COPPER



Subject:

GROVE BOX EXHAUST / CMM

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LINE. THE LOWER LEVEL CONSISTS OF THE 6"  $\phi$  GROVE BOX EXHAUST DUCT AND 4 - 4"  $\phi$  ELECTRICAL CONDUITS.

- 6) THE 6"  $\phi$  GROVE BOX EXHAUST DUCT IS AT THE UPPER LEVEL THROUGH THE 12' SPAN. JUST BEFORE IT REACHES THE CENTER TRAPEZE IT DROPS DOWN AT APPROXIMATELY A 45° ANGLE, WITHOUT COMING IN CONTACT WITH THE CENTER TRAPEZE, TO THE LOWER LEVEL. 2 FEET AFTER THE LAST TRAPEZE IT TAKES A 90° HORIZ. TURN WHERE IT IS TERMINATED WITH A PIN SUPPORT.
- 7) THE 4"  $\phi$  CMM PIPING IS AT THE UPPER LEVEL. JUST AFTER THE CENTER TRAPEZE IS TURNS 90° DOWNWARD AND ENDS WITH A FIXED SUPPORT. THIS END CONDITION MODELS WHERE THE LINE IS FIXED TO A PIECE OF EQUIPMENT.
- 8) ALL THE UPPER LEVEL PIPING TAKE A 90° TURN BETWEEN THE CENTER AND LAST TRAPEZE AND ARE TERMINATED WITH PIN SUPPORTS. IT WAS NOT KNOWN WHICH WAY THESE LINES TURNED BUT PHOTOGRAPHS INDICATED THAT THEY WERE PRESENT AT THE FIRST TWO SUPPORTS BUT NOT THE LAST ONE. IT WAS FELT TO BE IMPORTANT TO MODEL THE TURNS SO AS TO MORE EFFECTIVELY MODEL THE ACTUAL LONGITUDINAL STIFFNESS OF THE SYSTEM.

Subject:

GLOVE BOX EXHAUST / CNM

Job:

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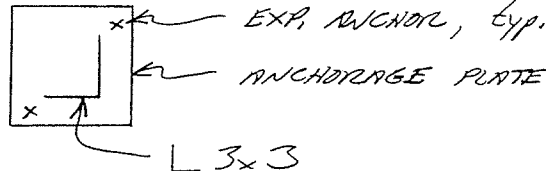
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- 9) ALL THE LOWER LEVEL PIPING TAKE A  $90^\circ$  TURN AFTER THE LAST SUPPORT, AS INDICATED BY THE PHOTOGRAPHS, AND TERMINATE IN PINNED SUPPORTS.
- 10) ALL THE TRAPEZE VERTICAL HANGERS, EXCEPT THE  $L 3 \times 3$ , HAVE FIXED END SUPPORTS TO MODEL THE EMBEDDED ANCHOR DETAILS PROVIDED BY THE ORIGINAL DRAWINGS. THE  $L 3 \times 3$  HAS A PINNED END SUPPORT TO MODEL THE FOLLOWING SUPPORT CONDITION OBSERVED ON THE SITE VISIT:



- 11) THE END CONDITIONS OF THE PIPING LINES THAT CONTINUE BEYOND THE BOUNDARIES OF THE MODEL ARE MODELED AS PINNED TO CREATE THE MOST FLEXIBLE CONDITION. THE MORE FLEXIBLE THE SYSTEM, THE HIGHER THE RESPONSE.
- 12) ALTHOUGH TRAPEZES HAVEN'T BEEN MODELED AT  $X=0$  AND AFTER THE TURN OF THE UPPER LEVEL PIPING LINES, TRANSVERSE SPRINGS HAVE BEEN ADDED TO THESE SUPPORTS WITH STIFFNESSES <sup>SM</sup> EQUAL TO THAT OF THE TRAPEZE FRAMES. <sub>Estimated</sub>

Subject:

GLOVE BOX EXHAUST / CCM

Job:

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- 13) THE ENDS OF THE LOWER LEVEL LINES AND THE 6"  $\phi$  GLOVE BOX EXHAUST DUCT AFTER THE TURN DO NOT HAVE SPRINGS SINCE THEY ARE CONNECTED TO A CONCRETE WALL.
- 14) THE TRAPEZES HAVE WELDED CONNECTIONS AND ARE MODELED WITH FULL MOMENT CONTINUITY.
- 15) EACH SPAN OF THE 6"  $\phi$  GLOVE BOX EXHAUST DUCT AND THE TWO 4"  $\phi$  CCM LINES HAVE NODES AT THE QUARTER POINTS TO CAPTURE THE HIGHER MODE RESPONSES. THE REST OF THE LINES HAVE A NODE AT THE MID-SPAN ONLY SINCE THEIR MODAL RESPONSES ARE OF A LESSEER IMPORTANCE TO THIS STUDY.
- 16) COMPUTER FILES ARE NAMED BCAMGBE

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**LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS**

*Volume 3*

**HJDA JOB #89089**

**JUNE 30, 1989**

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350 Sansome Street  
Suite 900  
San Francisco, CA  
94104

415-392-6952  
Fax 415-981-3157

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**VOLUME 3:      INCREMENT III ROOM EXHAUST  
DUCT SYSTEM**

Subject:

Room Exhaust

Job:

Bldg 332, U.N.C.

Job Number:

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Date:

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## Increment III

### Room Exhaust Duct System

(section 1 of report)

1.1) WORST CASE CRITERIA

1.2) MODEL DESCRIPTION

1.3) SAP90 MODEL DEVELOPMENT

36"  $\phi$  Duct

16"  $\phi$  Duct

1.4) Grand Response Spectrum

1.5) Room Exhaust Duct 36"  $\phi$  Analysis

A) Estimated response frequency

B) Dynamic Analysis Summary

C) Stress Check

D) Computer Output

1.6) Room Exhaust Duct 16"  $\phi$  Analysis

A- Estimate of frequencies

B) Dynamic Analysis Summary

C) Stress Check

D) Computer output



Subject:

RM. EXHAUST DUCT

Job:

UNL

Job Number:

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Date:

6/23/89

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WORST CASE CRITERIA:

GENERAL:

1. BASED ON THE RESPONSE SPECTRA USED, SYSTEMS WITH LOWER FREQUENCIES WILL HAVE HIGHER RESPONSES.
2. LOW FREQUENCY SYSTEMS WERE IDENTIFIED AS HAVING:
  - A. LONGEST SPANS
  - B. LARGEST MASS
  - C. LEAST MOMENT OF INERTIA
3. THEREFORE, THE CRITICAL CASES WERE DEFINED AS THE SECTIONS OF EACH SYSTEM THAT HAD THE LOWEST FREQUENCY.

ROOM EXHAUST SYSTEM SURVEY:

(BASED ON JUNE 15 FIELD INSPECTION AND AVAILABLE DRAWINGS.)

- LONGEST SPANS WERE IDENTIFIED AS 10'
- FOR SPANS OF THIS LENGTH, THE DUCT SIZES RANGED FROM 36" -  $\phi$  TO 16" -  $\phi$  IDENTIFYING THE LARGEST MASS AND LEAST MOMENT OF INERTIA CASES.



Subject:

Room Exhaust

Job:

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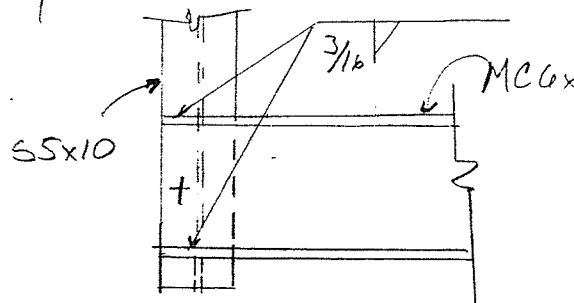
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## Room Exhaust System Analysis - Basement Inc III

- 1) Analyze 2 duct sizes, 36"  $\phi$  & 16"  $\phi$ , to compare results and select worst case loading on support system.
- 2) The computer model will include 2 spans of duct. The results at the center support are expected to represent worst case loads. This will be verified by the computer output.
- 3) The center support will include longitudinal braces (36"  $\phi$  only) consisting of  $2\frac{1}{2} \times 2\frac{1}{2}$  angles. The spacing of these braces is assumed to be at 20' O.C.. Comparison of demand forces to capacities of the braces will indicate if larger spacing is acceptable.
- 4) Connections to slab above are assumed fixed. This is reasonable for connections where the S5 x hanger is welded to an embedded channel anchor in the slab. PLZ71-332-043J & PLZ71-332-041J drawings provide embedded anchor details for original construction.
- 5) Continuity between the S5 x hanger and MCG cross beam is provided by connection webs.



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Room Exhaust

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- 6) The connections between the slab and the longitudinal braces ~~are~~ considered as pinned because of single bolt connections.
- 7) The 36"  $\phi$  duct is assumed to have 12 gage thickness based on notes from drawing PLZ 71-332-DG3 J (M-15).  
The 16"  $\phi$  duct is assumed to have 16 gage wall thickness.
- 8) The end conditions of the ducts are modeled as pinned in order to create the most flexible condition for duct vibration.
- 
- Any rotation restraint at the ends would increase the frequency of the duct and  $\therefore$  decrease the response.
- 9) Each span of duct will have nodes at the third points to capture higher mode shape responses.
- 10) Computer files are named: RMEX.36 & RMEX.16

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**LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS**

*Volume 4*

**HJDA JOB #89089**

**JUNE 30, 1989**

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350 Sansome Street  
Suite 900  
San Francisco, CA  
94104

415-392-6952  
Fax 415-981-3157

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**VOLUME 4:      INCREMENT III SUPPLY DUCT SYSTEM**

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ROOM SUPPLY

Job:

BUDG. 332, LLNL

Job Number:

89089

Date:

6/87

By:

J.A.H.

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## INCREMENT III

### ROOM SUPPLY DUCT SYSTEM

- 6.1) WORST CASE CRITERIA
- 6.2) SAP-90 MODEL DEVELOPMENT  
24" x 18" DUCT
- 6.3) GROUND RESPONSE SPECTRUM
- 6.4) ROOM SUPPLY DUCT 24" x 18" ANALYSIS
  - A. ESTIMATED RESPONSE FREQUENCY
  - B. DYNAMIC ANALYSIS SUMMARY
  - C. SYSTEM ELEMENT MASS CONTRIBUTION
  - D. STRESS CHECK
  - E. COMPUTER OUTPUT
- 6.5) FREQUENCY ANALYSIS - STIFFENED SUPPORTS
  - A. SUMMARY
  - B. COMPUTER OUTPUT
- 6.6) CHECK FOR OTHER CRITICAL SECTIONS
  - A. 36" x 36" DUCT



Subject:

ROOM SUPPLY DUCT

Job:

UNL

Job Number:

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WORST CASE CRITERIA

GENERAL:

1. SYSTEMS WITH LOWER FREQUENCIES WILL HAVE HIGHER RESPONSES
2. LOW FREQUENCY SYSTEMS WERE IDENTIFIED AS HAVING:
  - a. LONGEST SPANS
  - b. LARGEST MASS
  - c. LEAST MOMENT OF INERTIA
3. WORST CASE DEFINED AS THE SECTIONS OF EACH SYSTEM THAT HAD THE LOWEST FREQUENCY.

ROOM SUPPLY SYSTEM SURVEY:

(BASED ON JUNE 15 FIELD INSPECTION AND AVAILABLE DRAWINGS.)

- SECTION OF 24" X 18" DUCT WAS IDENTIFIED AS HAVING THE LONGEST SPANS (= 10'). IN ADDITION, SEVERAL CONDUITS WERE ADDED TO A UNISTRUT CHANNEL WELDED JUST BELOW THE DUCT, CONTRIBUTING A SIGNIFICANT AMOUNT OF MASS.
- SECTION OF 36" X 36" DUCT WITH SHORTER SPANS AND ADDITIONAL CONDUITS WAS IDENTIFIED AS NEXT CRITICAL

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**LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS**

*Volume 5*

**HJDA JOB #89089**

**JULY 17, 1989**

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Suite 900  
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**VOLUME 5:      INCREMENT I GLOVE BOX/ROOM  
EXHAUST SYSTEM -  
WEST SIDE OF LOFT**

Subject: INCREMENT I  
GLOVE BOX/ROOM EXHAUST

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Job: LINK #332

Job Number: 89089 Date: 6/89

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INCREMENT I & III  
GLOVE BOX EXHAUST  
AND  
ROOM EXHAUST  
SYSTEMS

(SECTIONS 7 & 8 OF REPORT)

4.1) WORST CASE CRITERIA

4.2) GLOVE BOX/ROOM EXHAUST SYSTEM  
WEST SIDE IN LOFT

4.2.1) DESCRIPTION OF WORST CASE

4.2.2) MODEL DESCRIPTION

4.2.3) SAP90 MODEL DEVELOPMENT

4.2.4) RESPONSE SPECTRA

4.2.5) ANALYSIS RESULTS

A) DYNAMIC ANALYSIS SUMMARY

B) STRESS CHECK

C) COMPUTER OUTPUT

4.3) GLOVE BOX EXHAUST SYSTEM  
EAST SIDE IN LOFT

4.3.1) DESCRIPTION OF WORST CASE

4.3.2) MODEL DESCRIPTION

4.3.3) SAP90 MODEL DEVELOPMENT

4.3.4) RESPONSE SPECTRA

Subject: INCREMENT I  
GLOVE BOX / LAB ROOM EXHAUST  
Job: LLNL, Bldg. 330  
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#### 4.3) GLOVE BOX EXHAUST SYSTEM - EAST SIDE IN LOFT (CONTINUED)

##### 4.3.5) ANALYSIS RESULTS

- A) MODEL CHECK
- B) DYNAMIC ANALYSIS SUMMARY
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#### 4.4) ROOM EXHAUST SYSTEM - EAST SIDE IN LOFT

- 4.4.1) DESCRIPTION OF WORST CASE
- 4.4.2) MODEL DESCRIPTION
- 4.4.3) SAP90 MODEL DEVELOPMENT
- 4.4.4) RESPONSE SPECTRA
- 4.4.5) ANALYSIS RESULTS

- A) MODEL CHECK
- B) DYNAMIC ANALYSIS SUMMARY
- C) STRESS CHECK
- D) COMPUTER OUTPUT

#### 4.5) GLOVE BOX EXHAUST SYSTEM - INCREMENT III, BASEMENT

- 4.5.1) DESCRIPTION OF WORST CASE
- 4.5.2) RESPONSE ANALYSIS
- 4.5.3) CONCLUSIONS

#### 4.6) SUPPLEMENTAL FIELD NOTES

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*SECTION 4.1*

*WORST CASE CRITERIA*

Subject:

INCREMENT I

GLOVE BOX / LAB ROOM EXHAUST

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Job: LNL H 332

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Date: 6-16-89

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By: JH

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## INCREMENT I

### GLOVE BOX & ROOM EXHAUST SYSTEMS

RATIONALE FOR SELECTION OF "WORST CASE" CONDITIONS FOR EVALUATION BY DYNAMIC ANALYSIS

#### GLOVE BOX SYSTEM

THE GLOVE BOX SYSTEM IS AN EXHAUST SYSTEM FOR THE GLOVE BOXES IN THE LABORATORIES. THIS SYSTEM IS WELL BRACED THROUGHOUT INCREMENT I. TWO "WORST CASES" ARE CONSIDERED - A PORTION OF THE LONGITUDINAL (NORTH/SOUTH) LINE ALONG THE WEST SIDE OF INCREMENT I IN THE LOFT, AND A PORTION OF THE LONGITUDINAL LINE ALONG THE EAST SIDE OF INCREMENT I IN THE LOFT. BOTH OF THESE SYSTEMS COLLECT EXHAUST FROM THE INCREMENT I LABORATORIES. BELOW. THESE "CASES" WERE CONSIDERED TO BE WORST CASES AS

- 1 - THE SYSTEM'S DUCTS ARE FAIRLY UNIFORM IN SIZE AND STIFF, AND WERE WELL BRACED THROUGHOUT THE BUILDING. HENCE, MAXIMUM ("WORST CASE") RESPONSE WOULD BE IN LOCATIONS WHERE FLOOR RESPONSE (FLOOR SPECTRAL ACCELERATIONS) WOULD BE HIGH AND WHERE THE SUPPORTS BRACING THE SYSTEM WOULD

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INCREMENT I

ETGUE BOX / LAB ROOM EXHAUST

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BE MOST FLEXIBLE, AS FLEXIBLE  
SUPPORTS COULD CREATE SYSTEM  
PERIODS TO THE REGION  
OF GREATEST ACCELERATION INDICATED  
ON THE FLOOR RESPONSE SPECTRA.

2 - THE MAXIMUM FLOOR RESPONSE  
SPECTRA OCCUR AT THE LEFT ROOF.  
AND BOTH OF THE CONDITIONS EVALUATED  
ARE SUPPORTED BY THE LEFT ROOF  
DIAPHRAGM.

3 - THE BRACING PROVIDED AT THE TWO  
CONDITIONS EVALUATED WAS  
DETERMINED BY EXAMINATION TO  
BE THE TWO MOST FLEXIBLE  
BRACING SYSTEMS.

4 - AS THE BRACING SYSTEMS FOR  
THE DUCTS AT THE EAST  
AND WEST SIDES ARE SIGNIFICANTLY  
DIFFERENT, BOTH CASES ARE  
EVALUATED, SEE (A) BOTTOM NEXT PAGE.

#### ROOM EXHAUST SYSTEM

THE ROOM EXHAUST SYSTEM IS AN  
EXHAUST SYSTEM FOR THE LABORATORY  
ROOMS. IN THE LABORATORY ROOMS  
THEMSELVES, THE INTAKE AND FILTER  
ARE AT THE FROUND FLOOR LEVEL  
AND THE DUCTS EXTEND VERTICALLY  
THROUGH THE FLOOR ABOVE (1ST FLOOR).  
THIS PORTION OF THE SYSTEM WAS  
EVALUATED IN 1981 BY STRUCTURAL  
MECHANICAL ASSOCIATES (SMA) AND FOUND  
TO BE ADEQUATE. IN THE WALKDOWN

Subject:

INCREMENT I

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GLOVE BOX/LAB ROOM EXHAUST

Job:

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Job Number: 89089

Date: 6-16-89

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IT WAS ALSO DEEMED TO NOT BE THE WORST CASE. TWO "WORST CASES" ARE CONSIDERED - A PORTION OF THE LONGITUDINAL (NORTH/SOUTH) LINE ALONG THE WEST SIDE OF INCREMENT I IN THE LOFT, AND A PORTION OF THE LONGITUDINAL LINE ALONG THE EAST SIDE OF INCREMENT I IN THE LOFT.

THE RATIONALE USED IN DETERMINING THE "WORST" CASES WAS THE SAME AS THAT USED FOR THE GLOVE BOX SYSTEM.

HERE TOO, BOTH THE EAST AND WEST SIDE BRACING SYSTEMS ARE EVALUATED DUE TO THE DIFFERENCES BETWEEN THE BRACING SYSTEMS.

#### NOTES (A)

- IN THE EVALUATIONS OF BOTH THE ROOM AND GLOVE BOX SYSTEMS, THE DUCT SPANS ARE TAKEN AS THE MAXIMUM SPANS SINCE THIS CAUSES THE PERIODS OF THE DUCTS TO BE LONGEST FOR MAXIMUM RESPONSE AND CAUSES THE MASSES TRIBUTARY TO THE SUPPORTING FRAMES TO BE MAXIMA CREATING LOWEST PERIODS AND MAXIMUM RESPONSES.
- SEE REPORT FOR MORE DISCUSSION.

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*SECTION 4.2*

*GLOVE BOX / ROOM EXHAUST  
SYSTEMS - LOFT, WEST  
SIDE*



Subject:

INCREMENT I

GLOVE BOX / LAB ROOM EXHAUST WEST SIDE

350 Sansome Street

San Francisco, CA

94104

415-392-6952

Job:

LLNL, Bldg. 332

Job Number:

89089

Date:

6-16-89

H. J. Degenkolb Associates, Engineers

By:

JHP

Section:

4.2.1

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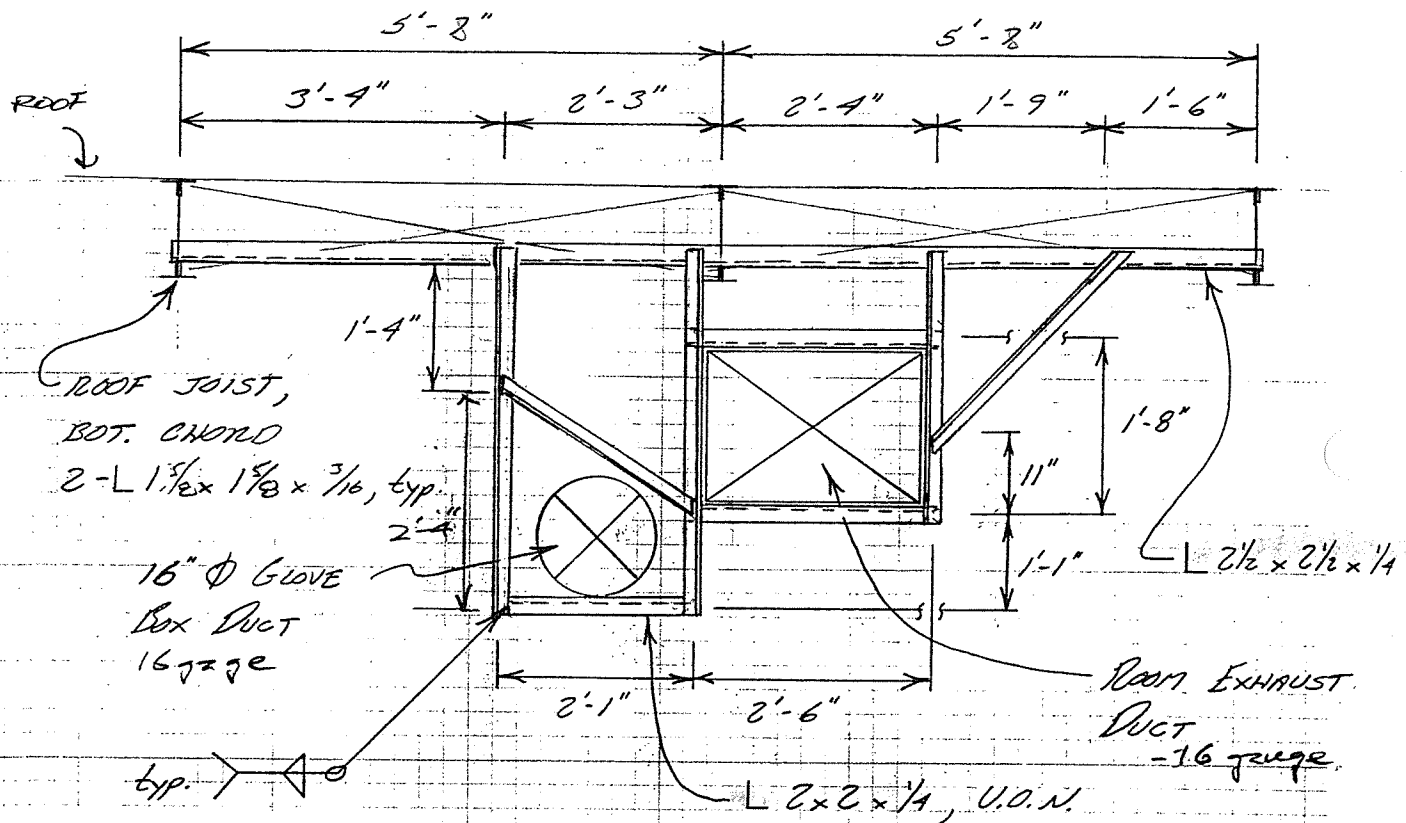
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GLOVE BOX / ROOM EXHAUST SYSTEMS:

INCREMENT I, LOFT, WEST SIDE -



ELEVATION SUPPORT FRAME

- Max. Spacing Between Frames = 14'-3"
- Joist Bridging Occurs @ Supports

Subject:

INCREMENT I  
REMOVE ROX (KAB ROOM EXHAUST WEST SIDE)

350 Sansome Street

San Francisco, CA

94104

415-392-6952

Job:

LAMP 332

Job Number:

89089

Date:

6/21/89

H. J. Degenkolb Associates, Engineers

By:

ME

Section:

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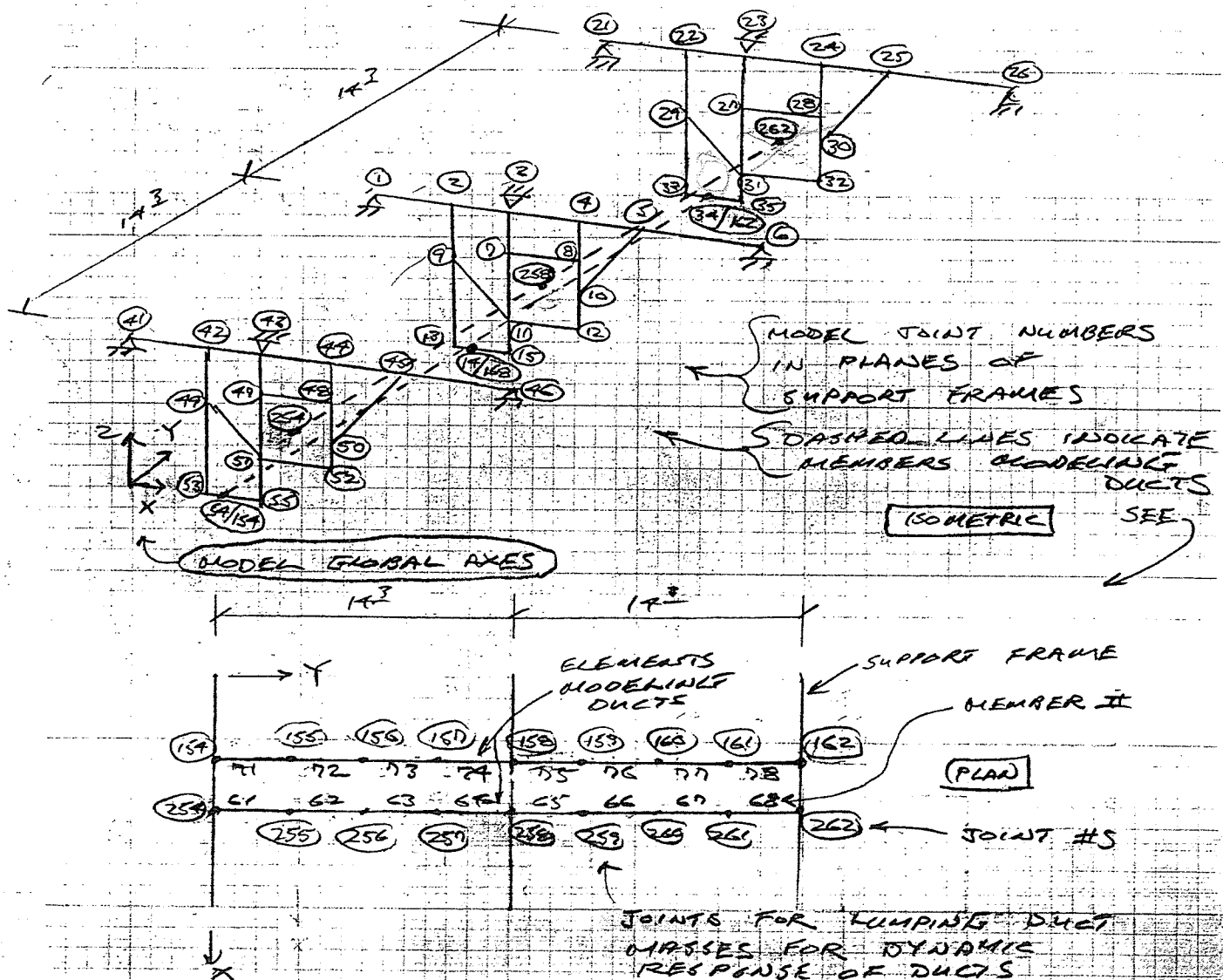
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- FLOOR (ROOF) RESPONSE SPECTRUM APPLICABLE AT TOP CHORD OF ROOF JOISTS. SINCE JOIST BRIDGING OCCURS AT DUCT BRACES, MODEL SUPPORTS AT BOTTOM CHORD LEVEL OF ROOF JOISTS
- SYSTEM BRACING DUCTS LONGITUDINALLY DEEMED ADEQUATE. HENCE, A DYNAMIC ANALYSIS FOR TRANSVERSE & VERTICAL SEISMIC LOADS WILL BE PERFORMED.
- MODEL A 2 BAY, 3 FRAME SYSTEM AS FOLLOWS:



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LLNL - BUILDING 332  
CRITICAL SYSTEM EVALUATION  
CALCULATIONS

*Volume 6*

HJDA JOB #89089

JULY 17, 1989

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350 Sansome Street  
Suite 900  
San Francisco, CA  
94104

415-392-6952  
Fax 415-981-3157

H. J. Degenkolb Associates, Engineers

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A California Corporation  
practicing in the broad field  
of Structural Engineering

**INDEX - CALCULATIONS**

**VOLUME 6:      GLOVE BOX EXHAUST - EAST SIDE OF  
INCREMENT I LOFT**

**ROOM EXHAUST - EAST SIDE OF  
INCREMENT I LOFT**

**GLOVE BOX EXHAUST - INCREMENT III  
OF BASEMENT**

**SUPPLY DUCT - INCREMENT I**



Subject: INCREMENT I

GLOVE BOX / LAB ROOM EXHAUST

Job: LLNL, Bldg. 332

Job Number: 89089 Date: 7-5-89

By: JFP Section:

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#### 4.3) GLOVE BOX EXHAUST SYSTEM - EAST SIDE IN LOFT (CONTINUED)

##### 4.3.5) ANALYSIS RESULTS

- A) MODEL CHECK
- B) DYNAMIC ANALYSIS SUMMARY
- C) STRESS CHECK
- D) COMPUTER OUTPUT

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- 4.4.1) DESCRIPTION OF WORST CASE
- 4.4.2) MODEL DESCRIPTION
- 4.4.3) SAP90 MODEL DEVELOPMENT
- 4.4.4) RESPONSE SPECTRA
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- A) MODEL CHECK
- B) DYNAMIC ANALYSIS SUMMARY
- C) STRESS CHECK
- D) COMPUTER OUTPUT

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- 4.5.3) CONCLUSIONS

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Subject: INCREMENT I  
GLOVE BOX/LOFT ROOM EXHAUST

350 Sansome Street  
San Francisco, CA  
94104  
415-392-6952

Job: LINK #332

Job Number: 89089 Date: 6/89

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By: MR Section: 4

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INCREMENT I & III  
GLOVE BOX EXHAUST  
AND  
ROOM EXHAUST  
SYSTEMS

(SECTIONS 7 & 8 OF REPORT)

4.1) WORST CASE CRITERIA

4.2) GLOVE BOX/ROOM EXHAUST SYSTEM  
WEST SIDE IN LOFT

4.2.1) DESCRIPTION OF WORST CASE

4.2.2) MODEL DESCRIPTION

4.2.3) SAP90 MODEL DEVELOPMENT

4.2.4) RESPONSE SPECTRA

4.2.5) ANALYSIS RESULTS

A) DYNAMIC ANALYSIS SUMMARY

B) STRESS CHECK

C) COMPUTER OUTPUT

4.3) GLOVE BOX EXHAUST SYSTEM  
EAST SIDE IN LOFT

4.3.1) DESCRIPTION OF WORST CASE

4.3.2) MODEL DESCRIPTION

4.3.3) SAP90 MODEL DEVELOPMENT

4.3.4) RESPONSE SPECTRA

Subject:

350 Sansome Street

San Francisco, CA

94104

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Job:

Job Number:

Date:

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*SECTION 4.3*

*GLOVE BOX EXHAUST SYSTEM -*

*LOFT, EAST SIDE*



Subject:

350 Sansome Street

San Francisco, CA

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Job:

Job Number:

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By:

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*SECTION 4.3.1*

*WORST CASE DESCRIPTION*

Subject:

GLOVE BOX EXHAUST - EAST LOFT

Job: LLNL, Bldg. 332

Job Number: 89089 Date: 6-16-89

By: JAP Section: 4.3.1

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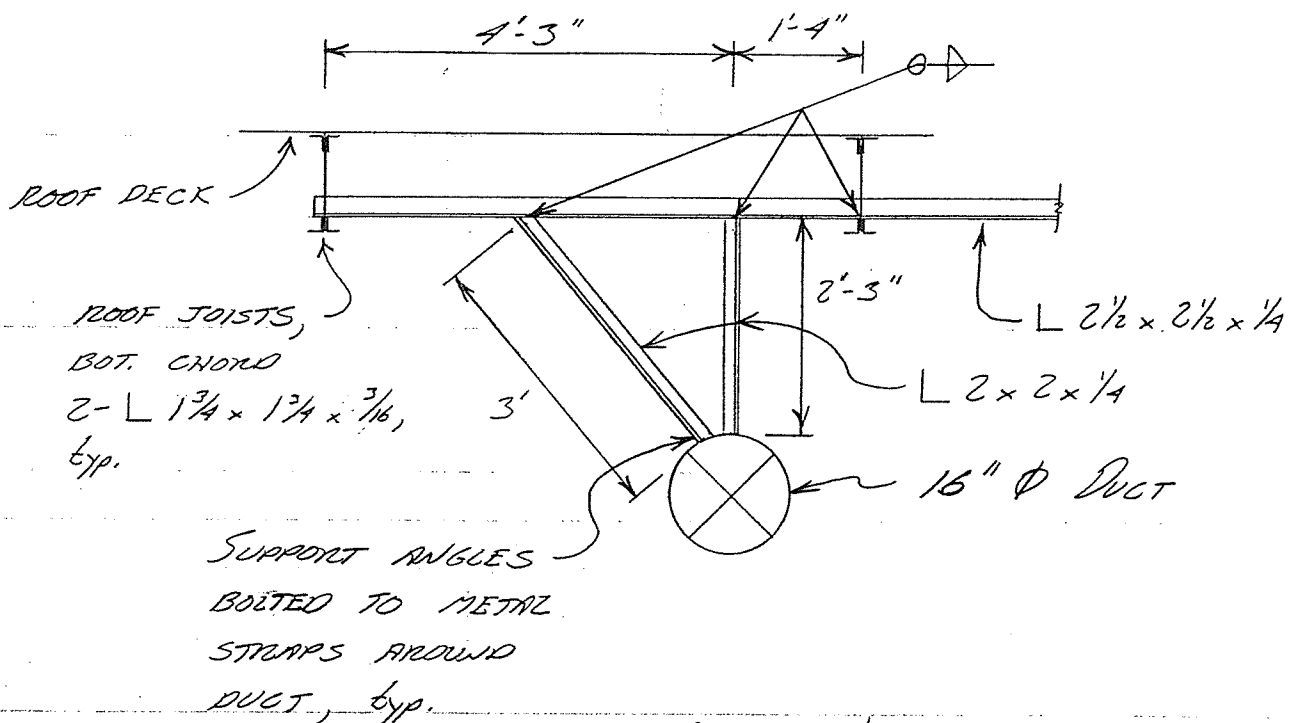
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GLOVE BOX EXHAUST - EAST SIDE, WORST CASE DESCRIPTION:

INCREMENT I, LOFT, EAST SIDE -



ELEVATION

- MAX. SPACING BETWEEN SUPPORTS = 16 FT.
- SUPPORT LOCATED FROM JOIST BRIDGING AT 21" ONE SIDE AND 34" ON THE OTHER.

Subject:

Glove Box Exhaust

Job:

UNL-Bldg 332

Job Number:

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SECTION 4.3.2

MODEL DESCRIPTION

Subject:

GLOVE BOX EXHAUST - EAST LOFT

Job:

20NL, BUDG. 332

Job Number:

89089

Date:

7-5-89

By:

JFP

Section:

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San Francisco, CA

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GLOVE BOX EXHAUST - EAST SIDE, MODEL DESCRIPTION:

- 1) ANALYZE THE STEEL ANGLE HANGER SUPPORTS AND THE 16"  $\phi$  GLOVE BOX EXHAUST DUCTS.
- 2) THE MODEL INCLUDES TWO FULL SPANS 16 FT. LONG WITH LUMPED MASS AND GRAVITY LOADS LOCATED AT THE ENDS OF THE DUCTS TO REPRESENT THE TRIBUTARY LOADS OF THE DUCT BEYOND THE BOUNDARIES OF THE MODEL. (SEE MODEL PLOTS AT THE END OF THIS SECTION)
- 3) THE TYPICAL SUPPORT HANGERS CONSIST OF A HORIZ.  $L 2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$  CONNECTED TO THE BOTTOM CHORD OF THE STEEL OPEN WEB ROOF JOISTS, 2- $L 1\frac{5}{8} \times 1\frac{5}{8} \times \frac{3}{16}$ . THE VERTICAL AND DIAGONAL HANGERS ARE  $L 2 \times 2 \times \frac{1}{4}$ .
- 4) DURING THE WALK-DOWN OF THIS SYSTEM IT WAS DETERMINED THAT THE LONGITUDINAL DIRECTION WAS ADEQUATELY BRACED. THEREFORE, THE MODEL WAS NOT ANALYZED FOR EARTHQUAKE FORCES IN THE LONGITUDINAL DIRECTION AND ANY REFERENCE TO FORCES OR MODAL RESPONSES IN THE LONGITUDINAL DIRECTION SHOULD BE NEGLECTED.
- 5) THE JOINTS AT THE ENDS OF THE HORIZ. CROSS MEMBERS <sup>ARE</sup> RESTRICTED FROM TRANSLATING IN THE VERTICAL AND LONGITUDINAL DIRECTIONS. THIS MODELS THE CONNECTION TO THE BOTTOM CHORD OF THE ROOF JOISTS.

Subject:

GROVE BOX EXHAUST - EAST LOFT

350 Sansome Street

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Job:

LLNL, Bldg. 332

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- 6) THE JOINTS ALONG THE BOTTOM CHORD OF THE ROOF JOISTS, ON EITHER SIDE OF THE JOINTS MENTIONED IN (5) ABOVE, ARE RESTRICTED FROM TRANSLATING IN ALL THREE ORTHOGONAL DIRECTIONS. THEY MODEL THE CROSS BRACING BETWEEN ADJACENT JOISTS.
- 7) THE DIAGONAL AND VERTICAL ANGLES HAVE FULL MOMENT CONNECTIONS TO THE HORIZ. CROSS MEMBER AND A PINNED CONNECTION TO THE DUCT.
- 8) THE DUCT HAS NODES AT THE QUARTER-SPAN POINTS TO CAPTURE THE HIGHER MODE RESPONSES OF THE DUCT.
- 9) COMPUTER FILES ARE NAMED LFTGLVEX.